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Crack Detection and Classification Based on New Edge Detection Method

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ABSTRACT

A methodology for the detection and removal of cracks on digitized paintings. The objective of this research is to develop an automatic crack detection system. The algorithm is composed of two parts; image processing and image classification. In the first step, cracks are distinguished from background image easily using the filtering, the improved subtraction method, and the morphological operation. The particular data such as the number of pixel and the ratio of the major axis to minor axis for connected pixels area are also extracted. In the second step, the existence of cracks are identified. Edge detection is used to automate the image classification.The recognition rate of the crack image was 90% and non-crack image was 92%. This method is useful for non-expert inspectors, enabling them to perform crack monitoring tasks effectively.

Keywords: cracks, crack detection, crack filling, restoration, in paintingand texture synthesis

1. INTRODUCTION AND REVIEW WORKS

Many paintings, especially old ones, suffer from breaks in the substrate, the paint, or the varnish. These patterns are usually called cracks. Cracking of the paint layers is one of the most common deteriorations in old paintings, arising inevitably with aging of the material. The level of this degradation is affected by many factors, from mechanical stress exposure to climate changes such as variations in temperature and humidity or pressurization (e.g., during air transport). In the past, several techniques for crack detection utilizing image processing have been reported [1-3]. Abdel-Qader et al. [4] and Hutchinson et al [5] used the Wavelet transform to detect cracks on concrete surfaces. We have also proposed crack inspection method using the Wavelet transform [6], [7]. Roli [8] and Hatada et al [9] considered the direction of cracks as a feature, and then they applied it to detect cracks on granite slabs and drains. Hatada et al [9] suggested that the computational cost reduction should be considered more, although they did not give the sufficient solution on this problem. IoannisGiakoumis, Nikos Nikolaidis [1] used thresholding for the detection and removal of cracks on digitized paintings and statistics filters or controlled anisotropic diffusion for crack filling. Tim Niemueller [2] used the concept of mathematical morphology and curvature evaluation to define crack-like patterns. WeihongWang , and Xujia Qin [3] proposed a novel algorithm for image inpainting based on compactly supported radial basis functions (CSRBF) interpolation. Ching-Tang HSIEH, Yen-Liang CHEN, and Chih-Hsu HSU [5] presents an accurate and fast image restoration for lost block images via wireless image transmission. Tomoyuki Yamaguchi,Shingo Nakamura Shuji Hashimoto [6] Crack detection on concrete surfaces is the most popular subject in the inspection of the concrete structures. Na WEI ,XiangMo ZHAO , XiaoYu DOU[10] proposed an algorithm for pavement cracks detection based on Beamlet Transform is proposed. Beamlet transform is a new tool for high dimensional singularity analysis. Yunjun Zhang Jiangjian Xiao Mubarak Shah [11] used Region completion method to fill in or remove stains of an image by using the information from the remaining area of the image N.

2. METHODOLOGY AND RESULTS

Image reconstruction has always a main issue in image processing. Old paintings usually suffer from cracks. These cracks may occur due to various reasons. Many materials are used altogether to make paintings like varnish, paint, glue, canvas, wood, metal, gilding and plaster. The surrounding environment affects the material of paintings. Several different reasons may contribute to formation of cracks like aging, drying, mechanical changes. Extreme changes in environmental factors like humidity and heat may leads to formation of cracks in paintings. Contraction in canvas, evaporation of volatile paint components or shrinkage in paint may also leads to appearance of cracks in paintings. Moreover, External causes like vibrations and impacts may cause painting deformations known as mechanical cracks[12-13].

The detection of cracks in painting and images is not a complexly new work to do there is already work performed on this problem by using other approaches. As we know the Image Processing includes the concept of image repairing and image enhancement. This repairing and image enhancement can be performed in terms of series of filters. There are different statistical and mathematical models to work with images.

We can perform the image enhancement by using different filters and as well as different sequence of the filters. In same way some work is already done by using different filters and approaches. The existing approach also divide the complete process of crack repairing in two stages. One for Detecting the Cracks and other is remove these cracks.

Existing approach is not very efficient in detecting cracks located on very dark image areas, since in these areas the intensity of cracked pixels is very close to the intensity of the surrounding region. Selecting a low threshold value and then apply the crack-detection algorithm on the dark image area may resolve this problem. Existing approach also do not work for crack that lies in regions of different color at the same time. So, filling of such cracks may lead to a situation, where crack from one area is filled with the color that should be filled in the crack of another area. It is shown in figure 1

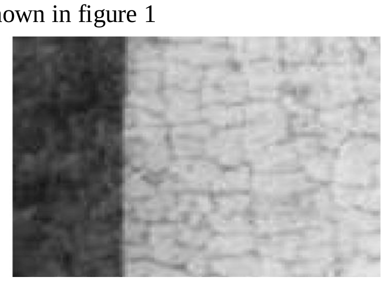

Figure 1: picture showing cracks that crosses border of different color.

Edge detection is most common approach for detecting meaningful discontinuities in gray level. The magnitude of first derivative can be used to detect the presence of an edge at a point in the image. The sign of second derivative can be used to determine whether an edge pixel lies on the dark or light side of an edge.

Edge detection is an important part of image pre-processing aimed to their segmentation and automatic recognition of their contents. Medical image analysis is critical in numerous biomedical applications such as detection of abnormalities, tissue measurement, surgical planning and simulation, and many more. In particular, image segmentation is an essential step, which partitions the medical image into different non-overlapping regions such that each region is nearly homogeneous and ideally corresponds to some anatomical structure or region of interest. It is the main tool in pattern recognition, object recognition, image restoration, image segmentation, and scene analysis. An edge detector is principally a high-pass filter that can be applied to extract the edge points in an image.

Process of identification of sharp discontinuities of an image is called edge of an image *i.e.*, edges are significant local changes of intensity. Here discontinuities mean abrupt changes of pixel intensity of image in a scene. Thus intensity causes basically geometric events and non-geometric events; geometric events basically discontinuity in depth and/or color and texture *i.e.*, object boundary and discontinuity in surface and/or color and texture *i.e.*, surface boundary and non-geometric events basically direct reflection of light called specularity and inner reflection or shadows from other object or same object. In high level image vision, edge detection is used in the interpretation of 3D objects from 2D images obtained from an image occlusion in radiological imaging. The goal of edge detection is to produce a continuous line drawing of a scene from an image of that scene. Important features can be extracted from the edges of an image (*e.g.*, corners, lines, curves) and these features are used by higher-level computer vision algorithms (*e.g.*, recognition) for analysis.

All edge detection algorithms are not involved with intensity change. Effects such as refraction or poor focus can result in objects with boundaries defined by a gradual and continuous change in intensity. Choosing a specific operator is dependent on responsiveness to such gradual change in intensity. Contemporary wavelet-based techniques describe the nature of the transition for each edge in order to distinguish edges.

There are many edge detection methods which are based on the gradients in the image. The methods return non-zero values in the uneven regions that typically occur on the boundary between two diverse regions in an image. There are large numbers of edge detection operators available, each designed to be responsive to certain particular types of edges. The majority of different methods may be grouped into two categories: i) The gradient method detects the edges by looking for the maximum and minimum in the first derivative of the image, ii) the Laplacian method searches for zero crossings in the second order derivative of the image to find edges.

The gradient is a vector which has certain magnitude and direction and the magnitude of gradient gives information about the strength of the edge and the direction of gradient is always perpendicular to the direction of the edge.
Any grayscale image is represented as a two-dimensional array of pixel intensities. A grayscale image can be expressed as a combination of k intensity values with a certain frequency f (k) where k = 0 to n.

In this research paper a new structure is proposed to represent images using a modified full and complete binary tree that will accommodate both the intensity and frequency measures. The objective in constructing such a tree is to obtain an image with reduced number of color, yet maintaining the full color palette; thus achieving color quantization at every tree level.

A binary tree can be defined as full binary tree if the entire node contains exactly two child nodes or it is leaf node and all leaf nodes must contains in the same level. Similarly a binary tree T with n levels is complete if all levels except possibly the last are completely full, and the last level has at least all its nodes to the left side. But in case of full and complete tree it must satisfy both the conditions laid down by their definitions. Hence it is possible to obtain a tree that is complete at all levels having all nodes and all child nodes; at the last level have only leaf node.

The proposed data structure, all the possible colour of an image can be represented by the leaf nodes of the said data structure i.e. if the image contains 2n number of distinct colours then the tree will have 2n leafs at level n. To represent a 256 grayscale DICOM image, it is required to construct a full and complete binary tree with leaf nodes at level 8 (as 28 equals 256). The node structure of the said binary tree will contain pointers for left and right child along with image data. The data will have three components i.e. colour intensity, its frequency present in the image and a balancing factor.

The frequency of intensity of left child node f(L) and right child node f(R), whichever is greater, will be the intensity of the parent node. The frequency for the node will be the summation of f (L) and f(R). The balancing factor will be determined by its level (l) and total number of colour intensity (C), for left node it will be balancing factor of parent node (C-2l) and for right it will be balancing factor of parent node.

Initially, a tree is created having level 8 with balancing factor as the only image data. At level 8 the value of balancing factor equals the intensity value; hence the balancing factor value is copied to the intensity data. The remaining two data fields of image data are empty in the beginning except the leaf nodes. Then the image bitmap is read in row major order. Each pixel's intensity will be compared with the balancing factor of each node starting from the root up to the last level. Every time it compares the intensity value with the balancing factor, to check whether it has a value greater or lower than the balancing factor. If it has a value lower than the balancing factor it moves on to the left child node for comparison. Similarly, if it is equal or greater than the balancing factor then it moves on to the right child node for comparison. Every time it will traverse a node the frequency value for that node will be incremented. At the end of the reading process, the tree contains frequency value of image data set for all the nodes in the tree, with the root node having the total pixel count whereas every leaf having the frequency value of that particular intensity.

The entire tree is constructed but only the leaf has all their image data set. In the next phase, the intensity value of image data for all the intermediate nodes including the root node are required to be calculated. As per the proposed algorithm the parent node will hold the intensity value of the child node that has a greater frequency among the two child nodes. To achieve the same the tree has to be traversed in post order manner. According to the post order traversal of tree the left child node and the right child node is traversed before the parent node, making it possible to compare the intensity frequencies of the child nodes. The intensity value of the parent node is updated based on the comparison results of the child nodes. This process is continued till the intensity value of the image data for root node is achieved.

The tree structure that is obtained by the above procedure contains the histogram of the original image with 256 grey shades at level 8 and in every subsequent upper level contains 2l number of grey shades. The intensity values of intermediate nodes can contain any grey shade value, thus preserving the original colour palette and performing uniform colour quantization at every level.

The above approaches have been used for edge detection because it results in better line drawing of an image and provide better results. Once the cracks detected the next work is to represent the area where these cracks are present. Now a manual input is required. A patch will be provided manually just to recognize the working area.

Once the area found the next work is to fill the cracks, to fill these we have to gather information pixels from surrounding pixels. For example we can take a matrix of 16x16 and find the average pixel value and replace the crack position pixel values by this new value it will replace the cracks. This is shown in figure 2, figure 3 and figure 4.

Figure 2 Conversion of Image to Gray Scale

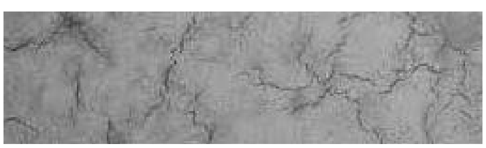

Figure 3 Removal of Cracks from the Gray Scaled Image

Figure4 Removal of Cracks

3. CONCLUSION

Edge detection is very significant step in any image segmentation and analysis algorithm. Proper classification of regions based on local intensity characteristics leads to prominent edges that isolate different anatomical regions as separate objects for further consideration. Presence of noise may hinder the process of edge determination. The proposed algorithm produces edge map image that is single pixel continuous edge line so edge thinning process is eliminated. The continuity of the edge line in the proposed algorithm ensures that process of edge linking is unnecessary. The most significant achievement of this proposed algorithm is that it is universally applicable to a wide range of medical imaging technology. Thus proposed work is an application of image restoration for image repairing using edge detection.

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